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Early-life risk factors identified for owner-reported feline overweight and obesity at around two years of age

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Abstract:

Obesity is considered the second most common health problem in pet cats in developed countries. This study used prospective data from a longitudinal study of pet cats ('C.L.A.W.S.', www.bristol.ac.uk/vetscience/claws) to identify early-life risk factors for feline overweight/obesity occurring at around two years of age. Data were collected via five owner-completed questionnaires (for cats aged two – six months, six months, 12 months, 18 months and two years respectively) completed between May 2011 and April 2015. Owner-reported body condition scores (BCS) of cats at age two years, assessed using images from

the 9-point BCS system (Laflamme, 1997), were categorised into a dichotomous variable: overweight/obese (BCS 6 – 9) and not overweight (BCS 1 – 5) and used as the dependent variable. Of the 375 cats with owner-reported BCS, 25.3% were overweight or obese at two years of age. Multivariable logistic regression models were built using stepwise forward-selection. To account for potential hierarchical clustering due to multi-cat households two-level random intercept models were considered but clustering had no impact on the analysis. Models were compared using Wald tests.. Six factors were significantly associated with overweight/obesity at two years of age: being overweight or obese at one year of age (OR=10.6, 95%CI 4.4 – 25.3); owner belief that BCS 7 was the ideal weight (OR=33.2, 95%CI 8.5 – 129.4), or that BCS represented overweight cats but they would not be concerned if their cat were classified in this category (OR=2.7, 95%CI 1.2 – 6.2), at questionnaire five completion; vets advising owners that the cat should lose weight, or making no comment on their weight, between one and two years of age (OR=12.1, 95%CI 3.2 – 44.9 and OR=3.9, 95%CI 1.5 – 10.3 respectively); owners giving their cat treats when they "felt happy" with them at 18 months of age (OR=2.7, 95%CI 1.0 - 7.3); feeding ≥250g wet food daily between two and six months of age (OR=2.7, 95%CI 1.2 – 5.9), and feeding dry food as the only or major part (> 50%) of the diet at two years of age (OR=2.1, 95%CI 1.0 – 4.2). These findings have the potential to reduce the current high prevalence of a widespread problem by informing preventive advice, and as such improve the health and welfare of pet cats.

Introduction

Feline obesity has become an extremely prevalent problem for pet cats, and indeed has been identified as the second most common health problem (after dental disease) in

45 domestic cats in developed countries studied to date (Cave et al., 2012). Obesity is
46 detrimental to health, predisposing animals to a variety of diseases and conditions, with
47 evidence that it also decreases quality of life and longevity (German et al., 2012; O'Neill et
48 al., 2015). Evidence from previous studies indicates that the prevalence of overweight and
49 obesity is already high by an early age (Kronfeld, Donoghue, & Glickman, 1994; Lund et al.,
50 2005; Scarlett et al., 1994). This suggests that the factors which significantly increase a cat's
51 risk of obesity occur early on in life, before adulthood is reached, which is supported by the
52 human literature on the importance of the early-life environment in the development of
53 childhood obesity an early-life critical period for the development of childhood obesity (eg,
54 Reilly et al, 2005).

55 Although numerous studies have already identified a number of risk factors for feline
56 obesity (see Rowe et al., 2015 for a summary), all of these studies bar two (Rowe et al.,
57 2015; Serisier et al., 2013) have been cross-sectional in design, where reverse causality
58 cannot be ruled out. Studies utilising prospective data are needed in order to provide
59 evidence for a predictive relationship between putative risk factors and obesity, if successful
60 preventive strategies are to be developed.

61 The aim of this study was to investigate early-life risk factors for feline obesity using
62 prospective data. The age period chosen to be investigated was from two months of age,
63 when most kittens are fully weaned and independent from their mothers, to two years, the
64 age at which obesity prevalence has been found to increase sharply (Scarlett et al., 1994). A
65 large number of potential risk factors were investigated, including feeding method, where
66 clear definitions were used to distinguish free choice and *ad libitum* feeding. Identifying risk
67 factors for feline obesity which occur early in life using prospective data from a large cohort

of owned pet cats will enable more effective preventive strategies to be developed, which are needed in order to reduce the prevalence of this serious health and welfare problem.

Materials and methods

Subjects

Data used in this analysis were from the 'Cat Longitudinal Analysis of Welfare Study' ('C.L.A.W.S.), a longitudinal UK-wide questionnaire-based feline health and welfare study. The inclusion criteria for 'C.L.A.W.S.' were that owners must live in the UK, be aged 18 years and over and own a cat aged approximately two to six months old in order to participate. Owners were recruited between May 2012 and May 2013 from rehoming organisations - mainly Cats Protection, the UK's largest feline welfare charity. By the end of the recruitment process, owners of 628 cats had completed the first questionnaire. These cats formed the study cohort for the 'C.L.A.W.S.' study.

Data collection

Data were collected via owner-completed questionnaires. Owners were requested to complete a questionnaire when they first adopted their kitten aged between two and six months old (Q1), followed by questionnaire two (Q2) when their cats reached 6.5 months of age, questionnaire three (Q3) at 12.5 months of age, questionnaire four at 18.5 months of age and questionnaire five (Q5) at 24.5 months of age. Most questions were 'closed questions' with multiple choice answers and questionnaires took 10–15 minutes to

90 complete. The majority of owners completed electronic questionnaires, although some
91 elected to complete paper questionnaires. Copies of the questionnaires can be obtained
92 from the corresponding author.

93

94 **Dependent variable**

95 Dual energy X-ray Absorptiometry (DEXA) is often used as the 'gold standard' for
96 measurement of body fat (German et al, 2006). The use of this was however beyond the
97 scope of the current study.

98 Instead the dependent variable used was owner-reported body condition score (BCS) at two
99 years of age (Q5) derived from owner-selected images from a choice of 5 images taken from
100 the 9-point body condition score (BCS) system, as only five images are included on the 9-
101 point system (Laflamme, 1997), thereby essentially becoming a 5-point system. The use of a
102 standard body condition scoring system combining images and text was avoided. This was in
103 an attempt to reduce reporting bias by owners, as previous research suggests that owners
104 tend to underestimate their cat's body condition (Allan et al., 2000; Kienzle and Bergler,
105 2006; Colliard et al., 2009; Cave et al., 2012) or normalise their judgement, underestimating
106 BCS of overweight cats and overestimating thin cats (Courcier et al., 2010). One potential
107 reason for this could be that the text descriptors used in body condition scoring systems
108 could be considered judgmental and emotionally loaded, such as discussion of fat layers,
109 and terms such as 'overweight', 'extremely overweight' and 'obese'. Furthermore,
110 unpublished work by the authors supported the use of images as the dependent variable, as
111 owners were found to be more accurate (i.e. showed better agreement with the 'gold

112 standard' of vet-assessed BCS) using images to assign a BCS to their cat rather than text
113 descriptions.

114

115 In questionnaires 3 (12 month old cats) and 5 (two year old cats), owners were asked to
116 select one of five images, depicting the view of a short-haired adult cat from the side and
117 above, which best represented their cat. These images corresponded to scores of 1, 3, 5, 7
118 and 9 on the 9 point scale. Images were not labelled with their corresponding score and the
119 order of the images was randomised using a random number sequence generator
120 (Random.org, 2015) so that the images were presented to all owners in the following order
121 in the questionnaire: score 5, 7, 9, 1, 3. This was in order to reduce the likelihood that
122 owners would choose the middle image solely because they inferred that this represented
123 the 'ideal' cat. As the outcome of interest in the current study was overweight and obesity,
124 scores were dichotomised into 'not overweight' (scores 1, 3 and 5) and 'overweight/obese'
125 (scores 7 and 9) for analysis.

126 In order to assess the accuracy of owner-reported BCS at two years of age, owner-selected
127 images were compared to the 'gold standard' of vet-reported BCS. This was done for cats
128 whose owners had returned a completed, clinic-stamped BCS card from their vet at
129 approximately 27 months of age, and where vet-reported scores corresponded with the
130 scores represented by the images (i.e. 1, 3, 5, 7 and 9), in order to enable a direct
131 comparison. A comparison was also made between dichotomised (not overweight vs.
132 overweight/obese) owner-reported and vet-reported BCS, which therefore enabled the
133 inclusion of vet-reported scores other than 1, 3, 5, 7 and 9. Cohen's Kappa score was used to
134 assess agreement, and interpreted based on suggestions by Viera and Garrett (2005). The

best way of comparing owner-reported BCS to true body condition would be to use DEXA, but this was beyond the scope of the current study.

Potential explanatory variables

The 376 variables which were extracted from data collected from Questionnaires 1-5 and analysed as potential risk factors for feline overweight/obesity are available as supplementary material. For variables with multiple categories, categories were combined if numbers in individual categories were small or when univariable analysis results suggested that this was appropriate, and if the combined categories were biologically plausible. Owner attachment was investigated in the third questionnaire using the 'Lexington Attachment to Pets Scale' (LAPS), developed and validated by Johnson, Garrity and Stallones (1992).

Descriptive statistics

Characteristics of the final cat cohort for which there was an outcome measure available are summarised: number of cats and owners, sex of cat, pedigree status (pedigree / non-pedigree), age of neutering, age at time of questionnaires one to five completion, diet type, feeding method and outdoor access. Number and percentage of cats which were overweight and obese at approximately two years of age (questionnaire five completion) according to both owner- and vet-reported BCS, and age at time of vet-reported BCS are given. Dichotomised owner-reported BCS at questionnaire five completion and vet-reported BCS at approximately 27 months of age were compared to assess agreement. Owner-

reported BCS at questionnaire three and five completion were compared to assess changes in BCS over time.

Missing data

There were 396 cats whose owners had completed the fifth questionnaires. Of these, 21 had missing data for the owner-selected BCS image used as the outcome measure, resulting in 375 cats forming the final study sample for analysis. However, some missing data for these cats existed for the potential explanatory variables, as not all owners had completed all questions and/or questionnaires. In addition, if owners selected 'don't know' for a question, these cats were excluded from the analysis for the variable derived from that question. This resulted in a different sample size for each potential explanatory variable in the univariable analysis.

In the first stage of multivariable analysis (the "grouped by questionnaire" multivariable models, see below), for each model, only cats for which there were no missing data for any of the variables were included. Because not all owners had completed all questions and/or questionnaires, and if owners selected 'don't know' for a question, these cats were excluded from the analysis, this resulted in a relatively large amount of missing data for this stage of the analysis. Sample sizes ranging from n = 162 to n = 224 (see Table 10).

Of the 375 cats, those with missing data for any of the variables eligible for inclusion in the multivariable analysis (n= 127) were excluded from the dataset used for multivariable analysis, in order to enable comparison of models. This resulted in 248 cats included in the final stage of the multivariable analysis. When two variables which were significant in a

179 previous study by the authors (Rowe et al., 2015) were added to the final model (see below
180 for details), there were missing data for 79 of the 375 cats on the variables to be tested,
181 resulting in a model with 296 cats.

182

183 **Statistical analysis**

184 Univariable analysis was first conducted using logistic regression models to screen all 376
185 potential explanatory variables for an association with the outcome of owner-reported
186 overweight/obesity at two years of age. Variables with a Wald test p-value <0.10 were
187 considered for inclusion in the multivariable analysis. Collinearity between variables which
188 were significant in the univariable analysis was assessed by calculating a Spearman Rank
189 correlation matrix. Variables which were found to be highly correlated ($|r|>0.9$) were not
190 included in the same multivariable model.

191 The first stage of the multivariable analysis involved analysing these variables in separate
192 multivariable logistic regression models for a binary response for predictors for each of the
193 five questionnaires. A similar "grouping" stage of the multivariable analysis has been
194 reported in previous risk-factor analyses for feline obesity (Allan et al., 2000; Cave et al.,
195 2012), although in these studies, variables were grouped according to "biologically sensible
196 groupings" (Cave et al., 2012). In the current study it was decided to group variables
197 according to questionnaire, as this would reduce the amount of missing data within groups
198 and all cats without missing data for the group of variables were included in the analysis (as
199 owners who completed one questionnaire may not have completed all subsequent or
200 previous questionnaires). The final stage of the analysis was then to build a combined
201 multivariable logistic regression model for a binary response using the significant variables

identified from the five questionnaire multivariable models. For both stages of the multivariable analysis ("grouped by questionnaire" models and combined models), multivariable logistic regression models were built using stepwise forward-selection i.e. potential explanatory variables were added to the model in order of significance according to the univariable analysis and Wald tests were used to test whether variables added to the model significantly improved the model, using a critical value of 0.05. Significant variables were retained in the model until no more significant predictors could be found, and this was deemed the final model. In the final model, first order interaction terms between significant variables which were biologically plausible were added and whether they significantly improved the model was assessed using Wald tests. In order to take into account potential hierarchical clustering of data due to some participants owning more than one study cat, the model was extended to a two-level random intercept model, with level two representing owner identification (level one represented cat identification), and compared to the single-level logistic regression model using Wald test p-values. This enabled differing owner-level effects on the probability of cats being overweight/obese to be tested. A second combined multivariable logistic regression model was built using only 'management' variables (i.e. diet and environmental variables, rather than cat characteristics and behaviour and owner and vet variables). This was in order to investigate risk factors for feline obesity which could be modified by owners in order to reduce the risk of obesity developing. Finally, although they had not been retained in the analysis model up to this point, two variables which had been found to be significantly associated with feline obesity in a previous study by the authors (Rowe et al., 2015) were added to the final stage of the model building process, in order to confirm whether or not they were still associated with the outcome. These were diet type and outdoor access at the time of outcome measure

(questionnaire five). All analyses were conducted using MLwiN version 2.33 (Rasbash et al., 2009).

Results

Dependent variable

According to owner-reported BCS at Questionnaire 5 completion, 25.3% (95/375) of cats were overweight or obese at approximately two years of age (see Table 3 for median and range of age of cats at Questionnaire 5 completion.

Reliability of dependent variable

There were 144 cats with both an owner-selected BCS image at questionnaire five completion and a vet-reported BCS at around two years and three months of age. When owner-selected BCS image and vet-assessed BCS were dichotomised into 'not overweight' and 'overweight/obese' i.e. the outcome measure of interest in this study, the agreement between owners and vets was rated as 'fair' and significant ($n = 144$, kappa = 0.299, $p < 0.0005$); Table 1 illustrates this comparison and also shows how owner's generally underestimate BCS. The age at time of BCS assessment by vets for these cats ranged from 24.3 to 31.8 months, with a median (interquartile range) of 26.7 (26.1 – 27.5) months.

According to vet-reported BCS, 36.8% of cats were overweight or obese (53/144), while only 37/144 (25.7%) were classified as overweight or obese by owners.

Table 1. A comparison between dichotomous owner-reported and vet-reported body condition score (BCS) based on data from the longitudinal questionnaire-based study 'C.L.A.W.S.' (UK, 2011 – 2015).

	Vet-reported body condition score[a] n = (%)[b]	
Owner-reported body condition score[c]	Not overweight	Overweight or obese
Not overweight	77 (84.6)	30 (56.6)
Overweight or obese	14 (15.4)	23 (43.4)

[a]Cats were scored by vets at around two years and three months of age using the 9-point BCS system (Laflamme 1997)

[b]Percentages expressed are of column totals

[c]Cats were scored by owners at around two years of age by selection of one of the 5 images taken from the 9-point system.

Descriptive statistics

The 375 cats forming the final sample for analysis (i.e. which had an outcome measure) were owned by 307 owners: 218 (71.0%) owners owned one study cat and 89 (29.0%) owned two study cats. Male cats formed 51.4% (n = 187) of the study cohort and females 48.6% (n = 177; data were missing on sex for 11 cats). The majority of cats were non-pedigree (92.0%, n = 333), with 8.0% pedigrees (n = 29, all of which were British Shorthairs; data were missing on breed for 13 cats). Age at neutering is summarised in Table 2 (data were missing on age at neutering for nine cats). Table 3 displays the age range and median and interquartile range for age of cats at time of completion of questionnaires one to five.

Table 2. Age of neutering of cats based on owner-reported data from the longitudinal questionnaire-based study 'C.L.A.W.S.' (UK, 2011 – 2015).

Age of neutering	Number (%) of cats[1]
2 months	59 (16.1)

3 months	80 (21.9)
4 months	70 (19.1)
5 months	43 (11.7)
6 months	89 (24.3)
7 months	11 (3.0)
8 months	9 (2.5)
9 months	4 (1.1)
20 months[2]	1 (0.3)
Total	366

[1] Data on age were missing for 9 cats

[2]This cat was was originally not neutered due to concerns reported by the owner about a heart murmur, a history of feline herpes virus, and the small size of the cat.

Table 3. The range, median and interquartile range of the age of cats at time of completion of questionnaires one to five in the longitudinal questionnaire-based study 'C.L.A.W.S.' (UK, 2011 – 2015).

Questionnaire	Age range in months	Median (interquartile range) age in months	n[1]
One (2 – 6 month old cats)	2.0 – 8.1	3.7 (3.2 – 4.6)	373
Two (6 month old cats)	5.0 – 9.3	6.7 (6.4 – 7.2)	354
Three (12 month old cats)	11.6 – 16.3	12.7 (12.5 – 13.2)	348
Four (18 month old cats)	17.5 – 22.9	18.8 (18.5 – 19.1)	355
Five (2 year old cats)	23.7 – 31.5	24.9 (24.5 – 25.5)	373

[1]Of the 375 cats forming the final sample for analysis (i.e. which had an outcome measure), there was missing data on age as not all owners completed every questionnaire

Table 4 and Table 5 illustrate the number and percentage of cats at the five questionnaire time-points fed different diet types and fed dry and wet food with different feeding methods, respectively. As cats increased in age, an increasing proportion were fed a dry diet. The majority of cats fed wet food were fed in meals, and a greater proportion of cats fed dry food were fed by free choice or ad libitum feeding compared to those fed wet food, over all five questionnaires.

Table 4. Number and percentage of cats fed different diet types at the five questionnaire time-points, based on owner-reported data from the longitudinal questionnaire-based study 'C.L.A.W.S.' (UK, 2011 – 2015).

Food Type	Number (%) of cats fed different diet types at questionnaire time-points				
Single food type diet[a]	Q1 (2-6 months)	Q2 (6 months)	Q3 (12 months)	Q4 (18 months)	Q5 (two years)
Dry[b]	80 (22.0)	96 (27.7)	128 (36.8)	132 (38.2)	152 (40.9)
Wet[c]	157 (43.3)	120 (34.7)	100 (28.7)	110 (31.8)	108 (29.0)
Fresh[d]	2 (0.6)	1 (0.3)	2 (0.6)	1 (0.3)	0 (0.0)
Mixed food type diet[e]					
Wet and dry	121 (33.3)	123 (35.5)	115 (33.0)	100 (28.9)	109 (29.3)
Dry and fresh	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.3)
Wet and fresh	1 (0.3)	1 (0.3)	3 (0.9)	2 (0.6)	2 (0.5)
Wet, dry and fresh	2 (0.6)	5 (1.4)	0 (0.0)	1 (0.3)	0 (0.0)
Total	363	346	348	347	372
Missing data	12	29	27	28	3

[a]Food type is major part (≥50%) or only food in diet.
[b]Dry kibble.
[c]Food in tins or foil pouches.
[d]Raw or cooked meat/fish.
[e]Each food type listed contributes equally to diet.

Table 5. Number and percentage of cats fed dry and wet food with different feeding methods at each of the five questionnaire time-points, based on owner-reported data from the longitudinal questionnaire-based study 'C.L.A.W.S.' (UK, 2011 – 2015).

	Q1 (2-6 months)	Q2 (6 months)	Q3 (12 months)	Q4 (18 months)	Q5 (two years)
Dry[a] food n = (%)					
Meals[b]	137 (41.3)	140 (56.5)	131 (42.0)	142 (45.2)	138 (41.6)
Free choice[c]	93 (28.0)	82 (33.1)	81 (26.0)	79 (25.2)	75 (22.6)
On request[d]	5 (1.5)	8 (3.2)	9 (2.9)	8 (2.5)	12 (3.6)
Ad libitum[e]	97 (29.2)	18 (7.3)	91 (29.2)	85 (27.1)	107 (32.2)
Total	332	248	312	314	332
Missing data	43	127	63	61	43
Wet[f] food n = (%)					
Meals	290 (89.8)	245 (87.8)	250 (90.3)	247 (88.2)	247 (86.4)
Free choice	14 (4.3)	11 (3.9)	8 (2.9)	12 (4.3)	15 (5.2)
On request	7 (2.2)	7 (2.5)	9 (3.2)	12 (4.3)	17 (5.9)
Ad libitum	12 (3.7)	16 (5.7)	10 (3.6)	9 (3.2)	7 (2.4)
Total	323	279	277	280	286

Missing data	52	96	98	95	89

[a]Dry kibble.
[b]Defined as feeding the cat portions of food two or more times a day.
[c]Defined as putting a specific amount of food in a bowl and leaving the bowl down all day for the cat to feed from in his/her own time but not refilling it again until the next day once it is empty.
[d]Defined as feeding every time he/she asks for food.
[e]Defined as filling the cat's bowl up and leaving it down all day but refilling it every time it is empty, or topping it up over the course of the day.
[f]Food in tins or foil pouches.

Table 6 compares vet-reported BCS at approximately 27 months of age with whether or not a vet commented on the cat's weight between one and two years of age.

Table 6. Vet-reported body condition score (BCS) at approximately 27 months of age and whether or not the owner reported that a vet had commented on the cat's weight from one – two years of age (asked in questionnaire five) based on owner-reported data from the longitudinal study 'C.L.A.W.S.' (UK, 2011 – 2015). BCS based on the 9-point system (Laflamme 1997). Percentages expressed are of row totals.

	Q5 Vet comment on cat's weight n = (%)[a]			
27 month vet-reported BCS	Yes, cat should lose weight	Yes, cat ideal weight	Yes, cat should gain weight	No
3	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)
4	1[b] (14.3)	5 (71.4)	0 (0.0)	1 (14.3)
5	0 (0.0)	36 (46.8)	2 (2.6)	39 (50.6)
6	5 (12.2)	18 (43.9)	0 (0.0)	18 (43.9)
7	3 (33.3)	0 (0.0)	0 (0.0)	6 (66.7)
8	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
9	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)
Total	10	62	2	64

[a]Percentages expressed are of row totals.
[b]This cat had a vet-reported BCS 6 at approximately 15 months of age so had lost weight since the vet recommended that the cat should lose weight.

Table 7 illustrates the number and percentage of owners who selected the image corresponding to BCS 3, 5 and 7 (no owners chose images of BCS 1 or 9) as representing an adult, short-haired cat with a "healthy optimal body size" at questionnaire one completion, therefore representing their perception of an ideal feline body condition at questionnaire one, when they first obtained their kitten. Table 8 displays the number and percentage of owners who selected statements they felt best applied to images corresponding to BCS 3, 5 and 7 at questionnaire five completion, therefore representing their perception of feline body condition later in cat ownership, when their cats were adults. The image owners selected to depict a cat with an ideal weight can be considered their perception of an ideal feline body condition at questionnaire five completion.

Table 7. Number and percentage of owners who selected the image corresponding to BCS 3, 5 and 7 (no owners chose the images of BCS 1 or 9) as representing an adult, short-haired cat with healthy, ideal weight at questionnaire one completion.

Q1 owner perception of ideal feline body condition[a]	Number (%) owners
BCS 3	15 (4.2)
BCS 5	318 (88.8)
BCS 7	25 (7.0)

[a]The body condition score (BCS) corresponding to the image reported by owners to represent an adult cat with a healthy optimal body size; BCS based on the 9-point system, where a score of 5 represents ideal body condition (Laflamme 1997)

Table 8. Number and percentage of owners who selected statements they felt best applied to images corresponding to BCS 3, 5 and 7 at questionnaire five completion

	Q5 owner perception of feline body condition		
	BCS[a] 3 n = (%)	BCS 5 n = (%)	BCS 7 n = (%)
Underweight and would concern me	187 (51.5)	7 (1.9)	0 (0.0)
Underweight and would not concern me	138 (38.0)	13 (3.5)	6 (1.6)
Ideal weight	30 (8.3)	344 (92.5)	41 (11.1)

Overweight and would concern me	5 (1.4)	2 (0.5)	171 (46.1)
Overweight and would not concern me	3 (0.8)	6 (1.6)	153 (41.2)
Total	363	372	371

[a]BCS = body condition score based on the 9-point system, where a score of 5 represents an ideal body condition (Laflamme, 1997)

Univariable results

Forty-seven variables were significantly associated with owner-reported overweight/obesity at approximately two years of age, based on a critical value of $p = 0.10$. These variables are available as supplementary material and were taken forward to the first stage of the multivariable analysis.

Multivariable analysis

There were no correlations where $|r| > 0.9$ between any of the 46 variables which were significant ($p < 0.1$) in the univariable analysis, indicating that any of these variables could be reasonably included together in the same model. Results of the first stage of the multivariable analysis, where significant variables were grouped according to questionnaire number and multivariable logistic regression models run for each questionnaire group separately, are displayed in Table 9. Eight variables were significant ($p < 0.05$) and taken forward to the second stage of the multivariable analysis, where a combined multivariable logistic regression model was run.

Table 9. Questionnaire group multivariable logistic regression models for risk factors for feline overweight/obesity at two years of age, based on owner-reported data from the longitudinal study 'C.L.A.W.S.' (UK, 2011 – 2015).

Variable name	Category	Odds Ratio (95% Confidence Interval)	p-value for variable	Overweight or obese n (%)	Not overweight n (%)
Questionnaire one for 2 – 6 month old cats (n = 172) [a]					
Q1 Reward with treat	Other response	1.00	0.040	30 (33.3)	104 (40.9)
	Give treat	2.27 (1.04 – 4.97)		15 (16.7)	23 (9.1)
Q1 Weight of wet food	< 250g	1.00	0.047	33 (36.7)	108 (42.5)
	250g or more	3.30 (1.25 – 8.75)		10 (11.1)	10 (3.9)
	It varies according to how hungry the cat is	0.75 (0.15 – 3.70)		2 (2.2)	9 (3.5)
Questionnaire two for 6 month old cats (n = 162)					
Q2 Reward with treat	Other response	1.00	0.004	29 (65.9)	102 (86.4)
	Give treat	3.30 (1.46 – 7.45)		15 (34.1)	16 (13.6)
Questionnaire three for 12 month old cats (n = 200)					
Q3 Dichotomous owner-reported BCS	Not overweight	1.00	<0.0005	25 (55.6)	140 (90.3)
	Overweight	7.46 (3.37 – 16.51)		20 (44.4)	15 (9.7)
Questionnaire four for 18 month old cats (n = 224)					
Q4 Reward with treat	Other response	1.00	0.041	32 (69.6)	150 (84.3)
	Give treat	2.27 (1.03 – 4.96)		14 (30.4)	28 (15.7)
Q4 How regularly go beyond garden	Every day	1.00	0.049	26 (56.5)	133 (74.7)
	N/A no outdoor access	0.49 (0.06 – 4.21)		1 (2.2)	8 (4.5)
	Several times a week	3.51 (1.55 – 7.99)		14 (30.4)	19 (10.7)
	1-2 times a week to less than monthly	1.01 (0.27 – 3.80)		3 (6.5)	15 (8.4)
	Never	3.37 (0.52 – 21.71)		2 (4.3)	3 (1.7)
Questionnaire five for 2 year old cats (n = 244)					
Q5 Belief of BCS 7 image	Overweight and would be concerned	1.00	<0.0005	10 (16.1)	104 (57.1)
	Ideal weight	50.30 (14.69 – 172.23)		19 (30.6)	5 (2.7)

	Overweight and would not be concerned	3.84 (1.72 – 8.56)		33 (53.2)	73 (40.1)
Q5 Vet commented on cat weight	Yes advised that cat was ideal weight	1.00	<0.0005	13 (21.0)	78 (42.9)
	Yes advised that cat should lose weight	15.06 (4.11 – 55.23)		10 (16.1)	6 (3.3)
	No comment made on cat's weight	2.46 (1.07 – 5.67)		39 (62.9)	98 (53.8)

[a]In this first stage of multivariable analysis, for each model, only cats for which there were no missing data for any of the variables were included. Because not all owners had completed all questions and/or questionnaires, and if owners selected 'don't know' for a question, these cats were excluded from the analysis, this resulted in a relatively large amount of missing data for this stage of the analysis.

Results of the combined model are shown in Table 10. Model 1 is the final model where all eight variables from the grouped analysis were included. Of the 248 cats included in the final model, 24.2% (n = 60) were overweight according to owner report. Model 2 displays the model built using only 'management' variables which were significant from the grouped analysis, and Model 3 displays the model where the two variables which were significant in a previous analysis (Rowe et al., 2015) were added to Model 1. There were no significant interaction terms for biologically plausible interactions in any of the three models. None of the coefficients or standard errors in any of the models changed by more than 0.0005 when a two-level hierarchical structure was included in the model, and a Wald test revealed that there was no significant improvement when controlling for owner-level variation and so single level models are reported only.

Table 10. Final multivariable logistic regression models for risk factors for feline overweight/obesity at two years of age, based on owner-reported data from the longitudinal study 'C.L.A.W.S.' (UK, 2011 – 2015).

Variable name	Category	Odds Ratio (95% Confidence Interval)	p-value for variable	Overweight or obese (%)	Not overweight (%)
Model 1 (n = 248)					
Q3 Dichotomous owner-reported BCS[a]	Not overweight	1.00	<0.0005	30 (50.0)	173 (92.0)
	Overweight/obese	10.58 (4.43 – 25.26)		30 (50.0)	15 (8.0)
Q5 Belief of BCS 7 image	Overweight and would be concerned	1.00	<0.0005	14 (23.3)	109 (58.0)
	Underweight	4.37 (0.33 – 57.59)		1 (1.7)	2 (1.1)
	Ideal weight	33.15 (8.49 – 129.44)		15 (25.0)	4 (2.1)
	Overweight and would not be concerned	2.67 (1.15 – 6.16)		30 (50.0)	73 (38.9)
Q5 Vet commented on cat weight	Yes advised that cat was ideal weight	1.00	0.001	11 (18.3)	81 (43.1)
	Yes advised that cat should lose weight	12.06 (3.24 – 44.93)		13 (21.7)	9 (4.8)
	No comment made on cat's weight	3.89 (1.47 – 10.33)		36 (60.0)	98 (52.1)
Q4 Reward with treat	No	1.00	0.044	44 (73.3)	163 (89.4)
	Yes	2.74 (1.03 - 7.29)		16 (26.7)	25 (13.3)
Model 2 (n = 248)					
Q4 Reward with treat	No	1.00	0.026	44 (73.3)	163 (86.7)
	Yes	2.28 (1.11 – 4.70)		16 (26.7)	25 (13.3)

Q1 Weight of wet food fed daily	< 250g	1.00	0.027	45 (76.3)	161 (85.6)
	250g or more	2.71 (1.24 – 5.94)		13 (22.0)	18 (9.6)
	It varies according to how hungry the cat is	0.42 (0.05 – 3.39)		1 (1.7)	9 (4.8)
Model 3 (n = 296)				(n = 75)	(n = 221)
Q3 Dichotomous owner-reported BCS	Not overweight	1.00	<0.0005	38 (50.7)	202 (91.4)
	Overweight/obese	10.31 (4.68 – 22.71)		37 (49.3)	19 (8.6)
Q5 Belief of BCS 7 image	Overweight and would be concerned	1.00	<0.0005	15 (20.0)	124 (56.1)
	Underweight	4.46 (0.36 – 55.78)		1 (1.3)	2 (0.9)
	Ideal weight	29.46 (9.45 – 91.82)		23 (30.7)	7 (3.2)
	Overweight and would not be concerned	2.80 (1.30 – 5.99)		36 (48.0)	88 (39.8)
Q5 Vet commented on cat weight	Yes advised that cat was ideal weight	1.00	0.002	14 (18.7)	94 (42.5)
	Yes advised that cat should lose weight	7.28 (2.19 – 16.81)		13 (17.3)	11 (5.0)
	No comment made on cat's weight	3.30 (1.43 – 7.63)		48 (64.0)	116 (52.5)
Q5 Dry diet	Other[b]	1.00	0.041	39 (52.0)	135 (61.1)
	Dry	2.07 (1.03 – 4.17)		36 (48.0)	86 (38.9)

[a]BCS = body condition score based on the 9-point system, where a score of 5 represents an ideal body condition (Laflamme 1997)

[b]Wet food (food in tins or foil pouches) fed as >50% of the cat's total diet, or a 50:50 mixture of wet and dry food

Discussion

Previous studies seeking to identify risk factors for feline obesity have been unable to rule out reverse causality for any associations identified due to their cross-sectional design. This study is the first (to the authors' knowledge) to utilise prospective data from a large-scale UK longitudinal study of owned pet cats in order to identify early-life risk factors for feline overweight/obesity at around two years of age.

Cohort characteristics

The majority of owners owned one study cat, resulting in only a small amount of clustering which may explain why the multivariable models were not changed by allowing for owner-level variation. The proportion of pedigree and non-pedigree cats in this cohort (8.0% and 92.0% respectively) were very similar to that reported by Murray and Gruffydd-Jones (2012): 7.6% and 92.4% respectively. As the population in the study by Murray and Gruffydd-Jones (2012) consisted of cats from a range of sources (pedigree breeders, non-pedigree breeders, bred by owner, rehoming organisations and bred by owners) and was randomly selected from a large UK-wide sampling frame, it could be considered to be a fair representation of the general UK cat-owning population in terms of pedigree status.

Overweight and obesity

According to owner-reported BCS, a quarter (25.3%, 95/375) of the study cohort were overweight or obese at approximately two years of age. According to vet-reported BCS, the proportion was even higher with over a third (36.8%, 53/144) being classified as overweight or obese. This study therefore adds to the evidence that the proportion of cats which are

411 overweight and obesity is already high by two years of age. The small difference in cat age
412 between owner-reported scores (median age at Q5 completion 24.9 months, interquartile
413 range 24.5 – 25.5 months) and vet-reported scores (median age 26.7 months, interquartile
414 range 26.1 – 27.5 months) is unlikely to account for the difference between owner and vet
415 scores, suggesting that the difference is due to incorrect owner perception of feline body
416 condition compared to vets, who are more likely to be more objective and accurate when
417 scoring cats due to lack of attachment and having more training and experience in scoring.

418

419 This study did not aim to estimate prevalence, due to the likely inaccuracy of owner-
420 reported data based on their tendency to underestimate their cat's body condition (Allan et
421 al., 2000; Cave et al., 2012; Colliard et al., 2009; Kienzle & Bergler, 2006), or normalise it
422 (Courcier et al., 2010). The estimated proportion based on vet-reported BCS may be more
423 reliable as these scores are considered to more accurately reflect true body condition than
424 owner-estimated scores (Shoveller et al., 2014). Nonetheless care should still be taken when
425 interpreting this estimate as there may still be biases in the study population, for example
426 owners may be more motivated than the general UK cat owner population as they have
427 voluntarily participated in a two-year long study. More motivated owners, for example, may
428 more closely monitor a cat's BCS, resulting in a lower prevalence of obesity than within the
429 general cat population. Conversely, more motivated owners may be more attached to their
430 cats, which has previously been shown to be a risk factor for obesity (Kienzle and Bergler,
431 2006), resulting in a higher prevalence than within the general population (although pet
432 attachment, as measured via the Lexington Attachment to Pets Scale, was not found to be
433 associated with overweight and obesity in this study).

Over half the cats (56.6%, n = 30) reported to be overweight or obese by their vet were regarded as not overweight by their owner. A smaller proportion (15.4%, n = 14) of cats which were not overweight according to vet-reported BCS were regarded as overweight or obese by their owners (Table 4). This tends to confirm the findings reported earlier that owners will more commonly under- than over-estimate the body condition of their cats. This suggests that owner training on body condition scoring is needed; however, this may also be considered at least partly an inevitable consequence of attachment biasing the objectiveness of an owner as scorer.

It should be noted that owner inaccuracy when scoring cats using the visual system in this study is unlikely to be due to the fur of cats obscuring the view of the cat's waist. This is because the proportion of long-haired cats in the present study was small (9.1% of the total original cohort, unpublished data).

Despite the evident scope for improvement in owner scoring-accuracy, the agreement between owner- and vet-reported scores was significant and fair, according to interpretation of the kappa statistic (Viera & Garrett 2005). This suggests that using dichotomous owner-reported BCS as an outcome measure can be considered a fair representation of vet scores, and therefore true body condition, if vet scores are taken to be the 'gold standard'. Using owner-reported scores rather than vet-reported scores as the outcome enabled a larger sample size to be used for analysis and so a robust power to detect significant associations between potential risk factors and feline obesity. As evidence from the current study and previous investigations suggest that owner-reported scores are likely to be an underestimate, the associations found between explanatory factors and outcome are likely to be conservative.

It should also be considered that vet scores may deviate from true BCS e.g. vets may not want to upset owners so underestimate the score of an overweight cat; time pressures of the consult may also result in inaccurate scoring by the vet, and vets may not necessarily be trained to score accurately using the 9-point system than owners.

Risk factor analysis

This study identified six factors which were independently associated with an increased risk of overweight or obesity being recorded at approximately two years of age in cats in the final multivariable analysis (Table 10, Models 1 - 3): overweight or obese status at approximately one year of age according to owner-reported BCS, owner belief that a cat with BCS 7 was the “ideal weight” or was “overweight but they would not be concerned” at questionnaire five completion; a vet advising that the cat should lose weight or making no comment on their weight between approximately one and two years of age, giving cats a treat when feeling happy with them at approximately 18 months of age, feeding 250g or more wet food per day at approximately two – six months of age, and feeding a dry diet at approximately two years of age. The multivariable model was not changed by allowing for owner-level variation, suggesting that any clustering due to multi-cat households had no impact on the conclusions. Each of the factors are discussed in turn below.

BCS at approximately one year of age

Cats which were reported by their owners to be overweight or obese at approximately one year of age were over ten times more likely to be reported by their owners as being overweight or obese at approximately two years of age, although the wide confidence interval suggests a degree of uncertainty in this result (Table 10, Model 1). A higher body weight at one year of age has previously been found to be associated with overweight and obesity in cats later in adulthood (Serisier et al., 2013). This is also seen in dogs: female dogs that were obese between nine and twelve months of age were 1.5 times more likely to become obese as adults (Glickman et al., 1995). Therefore this study highlights the importance of monitoring a cat's BCS very early in life, even before they reach one year of age.

Owner perception of feline body condition

Owners who believed at questionnaire five completion that a picture of a cat of BCS 7 was at an "ideal weight", were 33 times more likely to an own overweight or obese cats at two years of age compared to owners who believed that BCS 7 was overweight and it would concern them if their cat had this body condition, although a very wide confidence interval suggests further information is needed to confirm the magnitude of this association with greater certainty (Table 10, Model 1). Owners who believed at questionnaire five completion that a picture of a cat of BCS 7 was "overweight but they would not be concerned" if this picture represented the body condition of their cat were almost three times more likely to own overweight or obese cats at two years of age compared to owners who believed that BCS 7 was overweight and it would concern them if their cat had this body condition. Although previous studies have identified that owner underestimation (or

501 normalisation) of BCS is a risk factor for overweight and obesity (Allan et al., 2000; Cave et
502 al., 2012; Colliard et al., 2009; Courcier et al., 2010; Kienzle & Bergler, 2006), this is the first
503 study, to the author's knowledge, to investigate owner perception of feline body condition
504 as a risk factor in more detail.

505

506 When cats were approximately 2 – 6 months of age (Q1), 7.0% of owners believed that the
507 image of a cat with BCS 7 was ideal weight (Table 7), compared with 11.1% of owners at
508 approximately two years of age (Q5, Table 8). This suggests that, over time, some owners'
509 perception of body condition changes, so that more owners believe that an overweight cat
510 is a normal weight cat. With the growing prevalence of obesity in companion animals,
511 overweight could be becoming the new norm, as has been suggested for childhood obesity
512 (Coombes, 2014). As owner perception of feline body condition at questionnaire five was
513 associated with feline overweight and obesity at two years of age, this incorrect perception
514 of what is a 'normal' (i.e. ideal) body condition could be a causal factor in the development
515 of obesity in pets, and therefore contribute to the prevalence of the problem. However,
516 further study is needed to confirm this, due to the cross-sectional nature of this data in the
517 current study.

518

519 Furthermore, 41.2% (n = 153) of owners believed that a cat with BCS 7 was overweight, but
520 that it would not concern them if it were their cat. This finding of a lack of concern about
521 overweight cats from a large proportion of owners is supported by results from a previous
522 survey conducted in the USA and Australia, in which almost a third (32%) of owners
523 reported that their pet was overweight, but only 0.8% considered that this was a health

problem (Laflamme et al., 2008). These findings suggest a lack of awareness about the adverse health risks associated with being overweight.

These owners were 2.7 times (Table 10, Model 1) more likely to own an overweight study cat (according to owner-report). This suggests that a lack of concern may be contributing to the prevalence of the problem. If owners do not believe their cat's level of adiposity to be detrimental to health they may therefore take no measures to reduce their weight. Together the results outlined above suggest that owner education is needed on what constitutes a healthy feline body condition, as well as to explain the serious health consequences of obesity.

It should be noted that, as owner perception of feline body condition reported at questionnaire five, this data is cross-sectional (recorded at the same time as the outcome measure) rather than prospective. Therefore, this variable cannot necessarily be considered as a predictive risk factor for the development of obesity in cats. Nonetheless, it does add to the body of evidence highlighting the link between owner perception of feline body condition and feline overweight and obesity.

Vet comment on cat weight

A total of 124 cats had their weight commented on by their vet between one and two years of age (Table 6). Cats whose vet advised their owners that the cat should lose weight, between one and two years of age, were 12 times more likely to be overweight or obese at two years of age, compared to those whose vet advised they were ideal weight (Table 10

546 Model 1). This is logical as vets would be likely to only advise that overweight or obese cats
547 need to lose weight, and this may make owners aware that their cat is overweight or obese
548 and so be reflected in the owner-reported BCS in questionnaire five. However, perhaps
549 more interestingly, cats whose vets made no comment on their weight were almost four
550 times more likely to be overweight or obese at two years of age compared to those whose
551 vet advised they were ideal weight. Although based on small numbers of cats, these data
552 provide evidence that a large proportion of cats which are overweight were not reported by
553 owners as having the weight discussed with their owners by their vets (Table 6), despite
554 their vets performing a body condition assessment on the cat. Some caution should be
555 taken in interpreting this result, as it is based on owner-report: therefore some vets may
556 have discussed the cat's weight but owners did not report this, perhaps because they had
557 forgotten the conversation. Incorrect reporting by owners is possible: for example the
558 owner of a cat which was given a BCS of 9 by their vet reported that their vet advised that
559 the cat was ideal weight, which may seem unlikely.

560

561 The results support previous findings that vets tend not to discuss a cat's weight with
562 owners. McGreevy et al. (2008) revealed that vets completing a questionnaire on pet
563 obesity where they were asked to assess the BCS of cats they saw only informed the owner
564 of the cat's BCS in just under half the reported cases. Furthermore, vets may not just fail to
565 discuss weight with owners but fail to document the overweight or obese status on the cat's
566 medical record, suggesting that they may not consider the condition to warrant a formal
567 diagnosis. Records from 52 veterinary practices in the USA revealed that, of cats identified
568 as overweight(based on BCS assessed by the consulting vet for the purpose of the study),

only 3.2% had this diagnosis logged on their medical record, and of obese cats, only 21.5% (Lund et al., 2005). Even if a cat is not overweight or obese, a discussion about BCS with owners could be important so that owners can recognise an ideal body condition, in order to maintain their cats at a healthy body condition and identify if their cat is gaining or losing weight.

Rewarding with a treat

Owners who, when their cats were 18 months of age, reported that they gave their cat treats when they "felt happy" with them were almost three times more likely to have an overweight or obese cat at two years of age (Table 11, Model 1), compared to owners who rewarded their cat in other ways such as playing with them, stroking them or giving them a new toy. This reflects findings from Kienzle and Bergler (2006), who found that owners who used food as a treat (interpreted to mean a reward) were more likely to own an overweight cat compared to owners who used play as a treat. This association may be explained by the increased food intake from treats leading to a positive energy imbalance and so weight gain. In support of this, feeding treats several times a day was associated with a substantial increase in the risk of overweight and obesity at both questionnaire one and questionnaire two completion in the univariable analysis, compared to feeding treats less frequently or not at all.

Giving cats a treat when feeling happy with them may be viewed as a form of positive reinforcement, to reinforce a behaviour that the cat may have been performing to make the

591 owner feel happy with them (e.g. using the litter tray correctly, not scratching the furniture
592 etc.). However, if this is the case, other forms of rewards may be just as effective, especially
593 play. Play allows cats to exhibit their natural hunting behaviour which is thought to release
594 endorphins, for example just as they are released in humans following exercise (e.g. Harte,
595 Eifert, & Smith, 1995). This finding suggests that owner education on play as a better form
596 of rewarding cats may be one important way to help diminish a major risk factor for feline
597 overweight and obesity and so reduce the prevalence of this problem.

598

599 **Weight of wet food**

600 Cats which were fed 250g or more of wet food per day when aged between two and six
601 months old were almost three times as likely to be overweight or obese at approximately
602 two years of age compared to those which were fed less than 250g, when only
603 'management' variables were included in the final stage of the multivariable analysis (Table
604 10, Model 2). As discussed above, this early period before one year of age appears to be a
605 sensitive time when kittens are susceptible to factors affecting energy balance and which
606 contribute to obesity risk in adulthood. According to feeding guidelines and the energy
607 requirement formula for cats outlined by WALTHAM (Alexanderet al., 2010a), a 3kg cat has
608 a daily energy requirement of approximately 170 kcals, and the average wet food contains
609 between 75 – 100 kcal per 100g. Therefore feeding 250g of wet food would result in 188 –
610 250 kcal fed per day, a 10 – 47% excess in energy requirements. For two to six month old
611 kittens which weigh less than 3kg this weight of food will be in even greater excess of their
612 energy requirements. If a kitten eats all of their food and does not compensate with
613 increased energy expenditure, this will result in weight gain. It is possible that kittens may

be prone to overeating as satiety mechanisms may not have fully developed yet. This result suggests that owners should take extra care not to overfeed kittens with wet food, and should follow the feeding guidelines.

Feeding dry food

Cats fed dry food as the only or major part of their diet at approximately two years of age were twice as likely to be obese at two years of age, compared to those fed a wet diet or a 50:50 mixture of wet and dry food (Table 10, Model 3). This replicates the finding from a previous study by the current authors (Rowe et al. 2015), with a different cohort of cats, that a dry diet was associated with increased risk of obesity at 12.5 – 13 months of age. Therefore, this strengthens the evidence suggesting that dry food is a risk factor for feline obesity. A potential reason for this may be its high energy density: for the same weight, dry food contains approximately four times the number of calories as wet food (Alexander et al., 2010b). Feeding dry food may therefore lead to an increased risk of feeding above a cat's energy requirements: over-feeding even a small additional amount may lead to a large increase in calorie intake over energy requirements, compared to wet food. For a full discussion of dry food as a risk factor for feline obesity, see Rowe et al. 2015.

At questionnaire five, 40.9% of cats were fed a dry diet, compared to 29.0% that were fed a wet diet and 29.3% a 50:50 mixture of wet and dry food. This suggests that a dry diet was the most popular type diet fed to adult cats in this cohort. A dry diet for domestic cats has been found to be popular in other developed countries (Laflamme et al., 2008; Robertson, 1999; Scarlett et al., 1994). This suggests that a large proportion of cats are at increased risk of overweight and obesity due to their diet.

Conclusion

This work has found that within this cohort a quarter (25.3%) of cats were overweight or obese at approximately two years of age according to their owners, and over a third (36.8%) according to their vets. This supports previous findings that overweight and obesity is already high by a young age; however the study did not aim to estimate prevalence due to potential biases in the study population. There was fair agreement between owner- and vet-reported BCS, with owners tending to underestimate BCS, suggesting that owner education on body condition scoring is needed. The majority of cats which became overweight or obese at one year of age remained so at two years of age, and cats which were overweight or obese at approximately one year of age were over ten times more likely to be overweight or obese at approximately two years of age, highlighting the importance of preventative strategies which need to be put in place from a young age. There was evidence that vets tended not to discuss a cat's weight with the owner (according to owner report), even if the cat was overweight. Six factors were found to be independently associated with an increased risk of overweight or obesity at approximately two years of age according to owner-reported BCS: being overweight or obese at one year of age; owner belief that BCS 7 represented an 'ideal weight' cat or 'an overweight cat but that this would not concern the owner', at two years of age; vets advising owners that a cat should lose weight or making no comment on cat weight between one and two years of age; owners feeding cats treats when feeling happy with them at 18 months of age; feeding 250g or more of wet food per day at two to six months of age, and feeding dry food as the only or major part of a cat's diet at approximately two years of age.

The study highlights the importance of a cat's early environment in the risk of obesity developing in early adulthood and suggests that preventative measures need to be taken before a cat reaches one year of age. The results suggest that the following preventive measures may help to reduce the risk of obesity developing in the domestic cat. Owner education is needed on what is a healthy feline body condition and why they should be concerned about overweight in cats due to the negative health and welfare impacts. Vet education is needed on the importance of discussing a cat's weight with the owner. Owners should be encouraged to use forms of reward for their cat other than feeding treats (e.g. play), to feed their young kittens wet food according to their energy requirements, and to potentially avoid a completely or mainly dry diet, or pay careful attention to the amount of food fed, opportunities for exercise and BCS of cats fed a dry diet. These results can be used to inform evidence-based preventive strategies for feline obesity, ie, preventive advice given to kitten owners by veterinary and cat care professionals, and so potentially help to reduce the prevalence of this widespread problem.

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